Methodology for Estimating Equal Value Life-Year for Standard Three-State Partitioned Survival Models

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Introduction

- Equal value life-year (evLY) is gaining popularity as an alternative to quality-adjusted life-year (QALY) as a measure of health gain for medical policy decisions.
- Like QALY, evLY compares the improvements or decrements in quality of life (QoL) across different interventions.
- However, when modelling serious illness or chronic disability, the QALY approach often assigns a lower utility weights to life extensions, thereby undervaluing the benefits of a new intervention.
- evLY overcomes this limitation by assigning a population-based average utility to life extensions. While Campbell and colleagues (2023) demonstrated how to measure evLY for a two-state model (alive and dead), they didn't present a generalizable approach for calculating evLY for models with more than more than two states.[1]

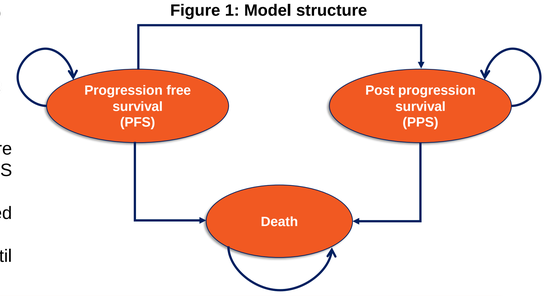
Objective

- Our objective for this study is to present an approach for estimating equal value life-year gained (evLYG) for standard three-state partitioned survival models (PSMs).

Methods

- We developed a hypothetical three-state partitioned survival model (PSM) for two hypothetical drugs, Drug A and Drug B (**Figure 1**). All patients enter the model in progression free survival (PFS) state, while in this state, patients may progress to post progression survival (PPS) health state or die. Once patients move to the 'post-progression' health state, they cannot return to 'progression-free' state and are at risk of death.
- We assumed a cycle length of one month and a time horizon of five years for this analysis. We only performed undiscounted analysis for the sake of parsimony.
- Drug A was assumed to be the current standard of care with 6.1 months of median PFS (mPFS) and 12.3 months of median overall survival (mOS). Drug B was assumed to be a new intervention with superior mPFS (10.2 months) and mOS (22.3 months). PFS and OS state patient disposition was estimated by assuming constant hazard rate. An alternative base case was considered in which mPFS for drug B (13.5 months) was higher than mOS for drug A (12.3 months).

Figure 1: Model structure



- In this hypothetical example, health-state-specific utility weights were applied, with values of 0.726 for the PFS state and 0.512 for the PPS state.
- The methods used to estimate evLYG for both scenarios are presented in **Table 1**.
- **Figure 2 and 3** illustrate the survival curves for Drug A and Drug B until the 5-year time horizon.

Table1: Methods for Estimating the Equal Value of Life-Years Gained Outcome

OS_t^A = *Overall survival at time t for Drug A (comparator)*
PFS_t^A = *Progression−free survival at time t for Drug A*
OS_t^B = *Overall survival at time t for Drug B (intervention)*
PFS_t^B = *Progression−free survival at time t for Drug B*
U_{PFS} = *Utility applied to patients in PFS state*
U_{PPS} = *Utility applied to patients in PPS state*
0.851 is considered as average utility of the general adult population[1]

Given that $\mathrm{OS_t^B} \geq \mathrm{OS_t^A}$

The incremental survival gain can be defined as (see **Figure 1** and **Figure 2**), $\Delta\mathrm{OS_t^G} = \mathrm{OS_t^B} - \mathrm{OS_t^A}$

Case 1: Base case

In this case, mPFS on drug B is lower than mOS on drug A (see **Figure 1**), $\mathrm{OS_t^A} \geq \mathrm{PFS_t^B}$

Then PPS on drug B could be described as, $\mathrm{PPS_t^B} = \Delta\mathrm{OS_t^G} + \mathrm{OS_t^A} - \mathrm{PFS_t^B}$

Then, $evLY_t^B = 0.851 * \Delta OS_t^G + (\mathrm{OS_t^A} - \mathrm{PFS_t^B}) * \mathrm{U_{PPS}} + \mathrm{PFS_t^B} * \mathrm{U_{PFS}}$

$$\boldsymbol{evLYG_t = 0.851 * \Delta OS_t^G + (OS_t^A - PFS_t^B) * U_{PPS} + PFS_t^B * U_{PFS} - QALY_t^A} \quad \textbf{... (1)}$$

Suppose the model has a time horizon of X years and is divided into n cycles, then the total evLYG can be expressed as;

$$\boldsymbol{evLYG = \sum_{t=1}^{n} evLYG_t}$$

Case 2: Alternative base case

In this case, mPFS on drug B is higher than mOS on drug A (see **Figure 2**), $\mathrm{PFS_t^B} \geq \mathrm{OS_t^A}$

$evLY_t^B = 0.851 * \Delta OS_t^G + OS_t^A * \mathrm{U_{PFS}}$

$$\boldsymbol{evLYG_t = 0.851 * \Delta OS_t^G + OS_t^A * U_{PFS} - QALY_t^A} \quad \textbf{... (2)}$$

Suppose the model has a time horizon of X years and is divided into n cycles, then the total evLYG can be expressed as

$$\boldsymbol{evLYG = \sum_{t=1}^{n} evLYG_t}$$

Figure 2: Base case: PFS and OS for [Drug A] and [Drug B]

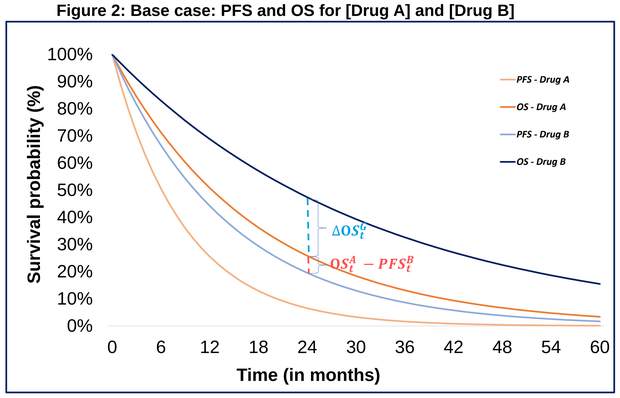
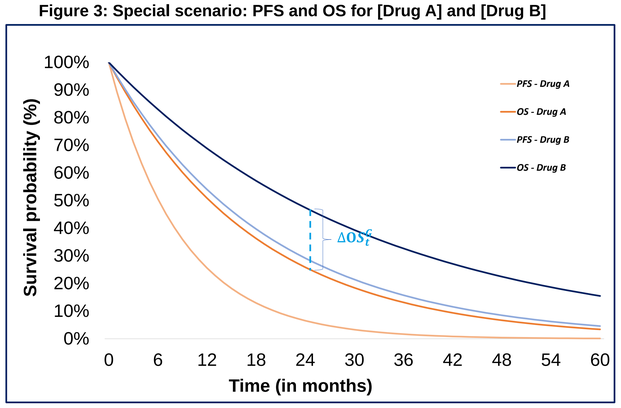


Figure 3: Special scenario: PFS and OS for [Drug A] and [Drug B]



Keys: evLY, equal value life-year; evLYG, equal value life-year gained; OS, overall survival; PFS, Progression free survival; PPS, Post progression survival

Results

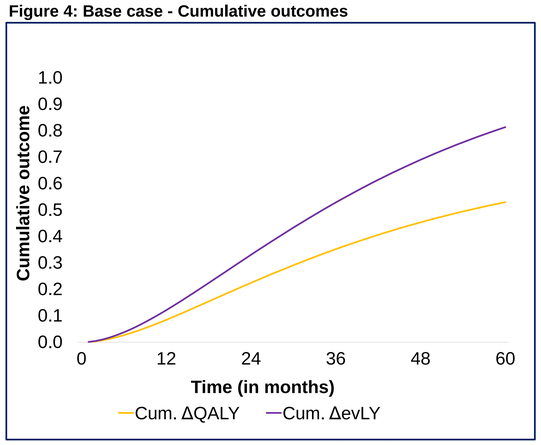
Case 1: Base case (mPFS for Drug B is lower than the mOS for Drug A)

- In the base case, using Equation 1, we calculated incremental evLY to be 0.813, compared to an incremental QALY of 0.530.
- **Figure 4** compares the cumulative incremental QALY and incremental evLY for the base case.

Case 2: Alternative base case (mPFS for Drug B is higher than the mOS for Drug A)

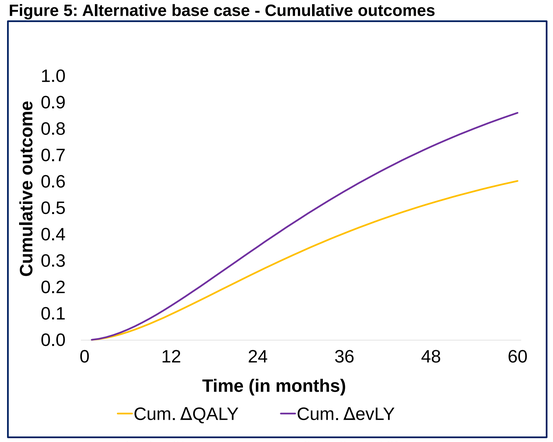
- In the alternative base case, using Equation 2, we calculated incremental evLY to be 0.861, compared to an incremental QALY of 0.603.
- **Figure 5** compares the cumulative incremental QALY and incremental evLY for the alternative base case.

Figure 4: Base case - Cumulative outcomes



Keys: evLY, equal value life-year; QALY, quality adjusted life year

Figure 5: Alternative base case - Cumulative outcomes



Keys: evLY, equal value life-year; QALY, quality adjusted life year

Conclusion

- This study explores the methodological approach for integrating the evLYG outcome into a PSM.
- The approach proposed here allows for an easy estimation of evLYG for a three-state PSM. However, further research is needed to generalize evLYG calculations for n-state models.
- Providing a detailed explanation of the methods used to estimate evLYG in future model publications will enhance transparency and reproducibility of findings.

Reference

1. Campbell JD, Whittington MD, Pearson SD. An Alternative Measure of Health for Value Assessment: The Equal Value Life-Year. Pharmacoeconomics. 2023;41(10):1175-82.